



Armed Forces College of Medicine

AFCM



Electron Transport Chain **& Oxidative phosphorylation**

By

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INTENDED LEARNING OBJECTIVES (ILO)



• *By the end of this lecture the student will be able to:*

1. Discuss the components of the ETC & their arrangement on the inner mitochondrial membrane.
2. Explain the chemiosmotic theory and the coupling of oxidation to phosphorylation.



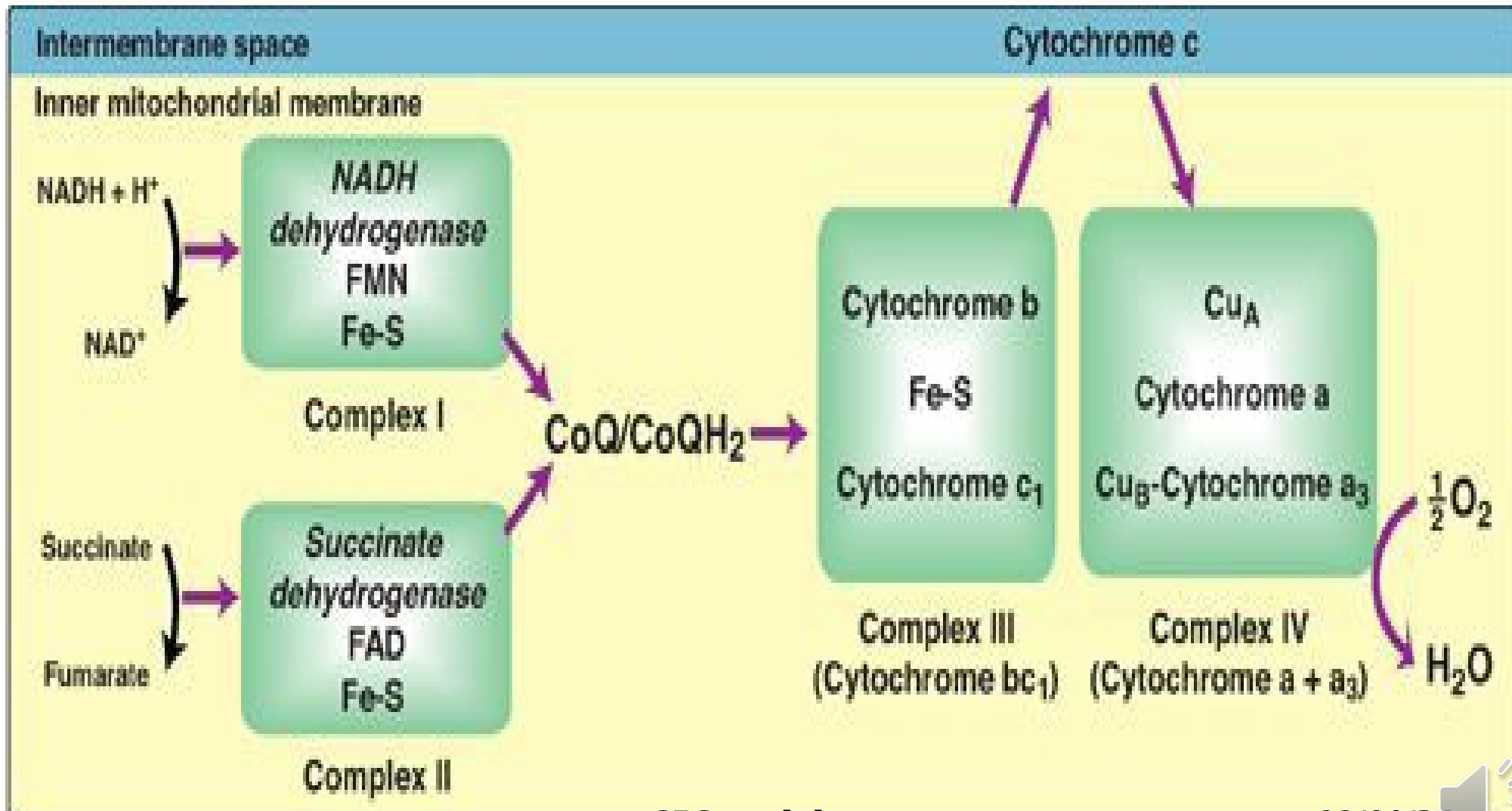
ETC components are arranged in the inner mitochondrial membrane forming **5 complexes**



- **Complex I** = NADH **Dehydrogenase**
- **Complex II** = Succinate **Dehydrogenase**
- **Complex III** = Cytochrome **C Reductase** (b-c₁)
- **Complex IV** = Cytochrome **C Oxidase** (a-a₃)
- **Complex V** = **ATP synthase Complex**



Respiratory chain consist of enzymatic complexes



Complex I



“NADH dehydrogenase”

It collects the **NADH**

& associated with **CoQ**.

oxidation of one NADH and transfer of
two electrons to ubiquinone



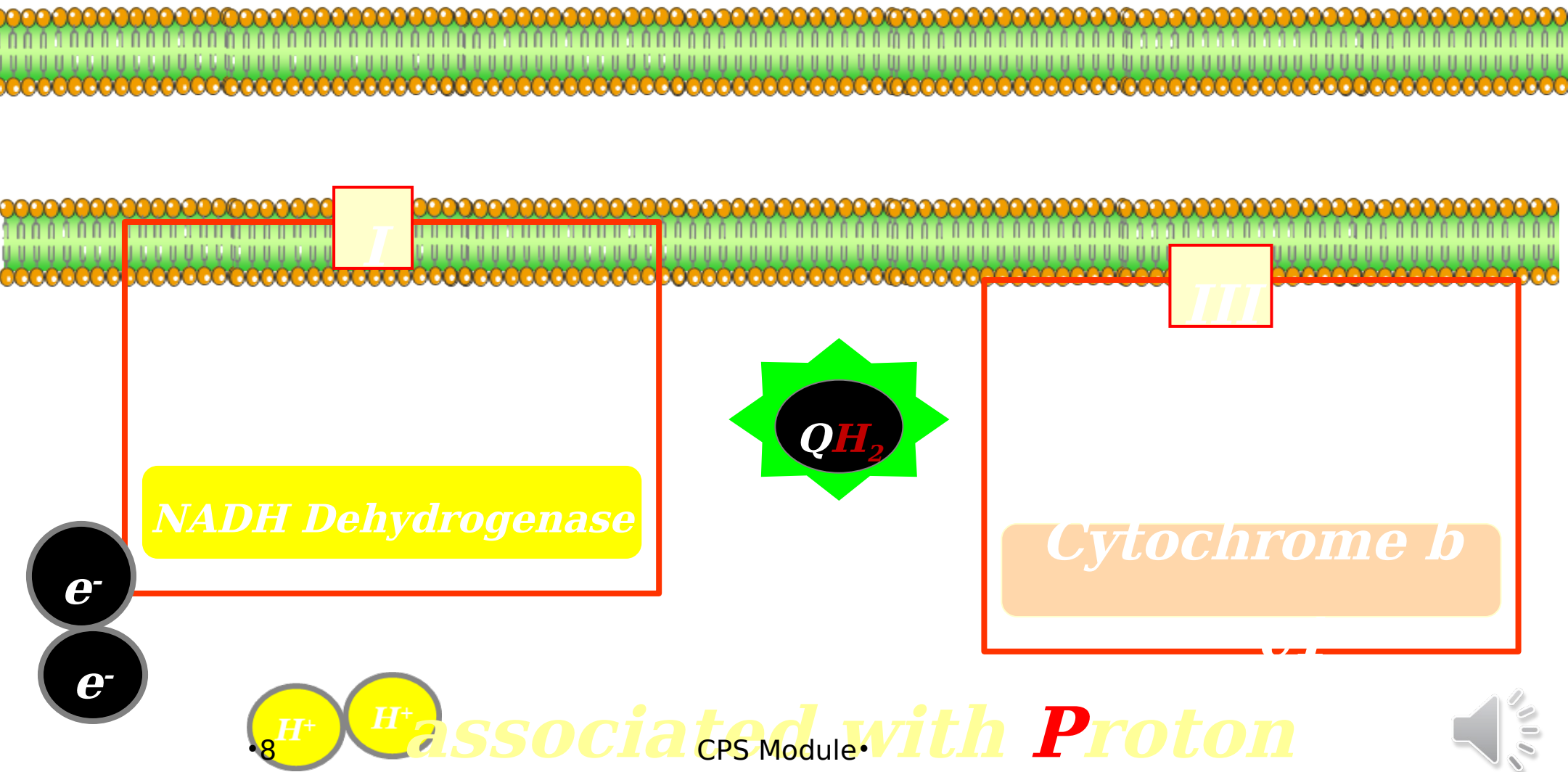


Complex I

- During oxidation of one NADH and transfer of two electrons to ubiquinone by complex I, two protons are pumped across the mitochondrial membrane from the matrix side (N for negative face) to the cytosolic side (P for positive face). The energy released during oxidative reactions occurring in complex I is conserved by concomitant pumping of protons across membrane.



Complex I & Co Q



Complex II



“Succinate Dehydrogenase”
It is associated with CoQ



It is the **entry point of FADH_2**

the transfer of electrons

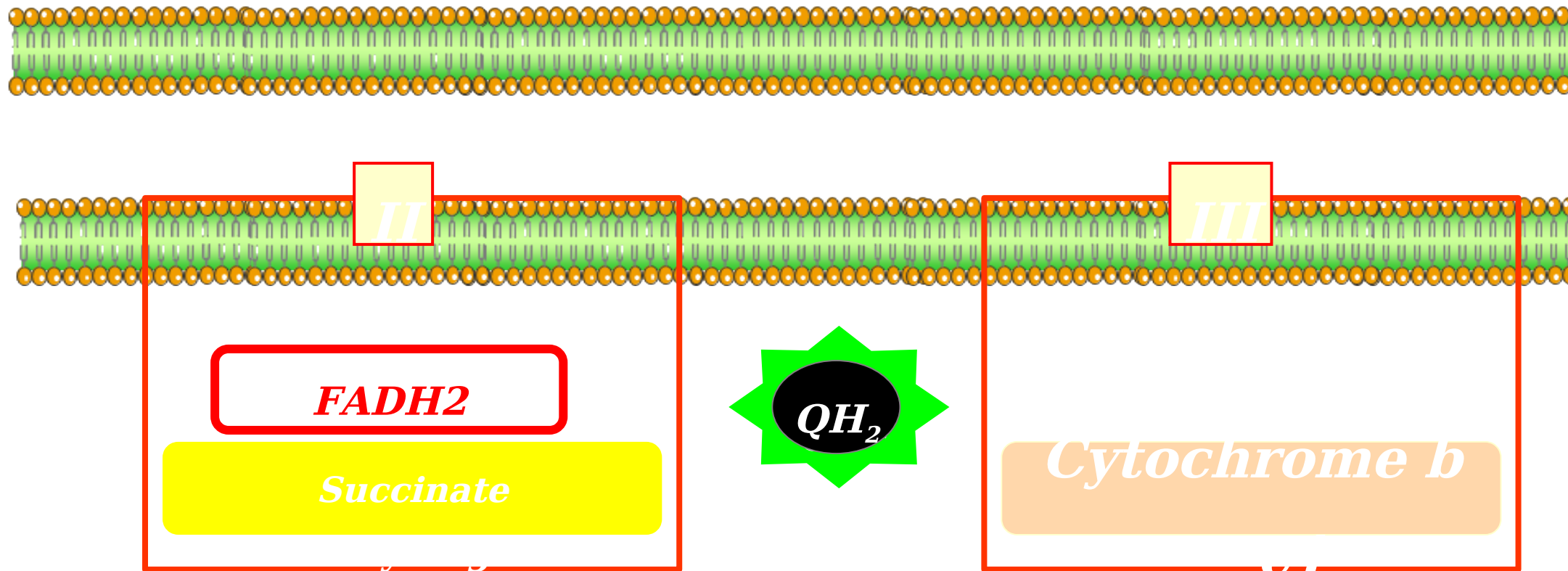
from **FADH_2** to CoQ

It is Not associated with Proton Pump !!

Because It does Not ***traverse the whole length of the inner mitochondrial membrane.***



Complex II & Co Q



It is ~~Not~~ associated with Proton

•11 CPS Module•

Wednesda



Student activity

Which of the following mitochondrial enzymes is FAD dependent?

A. Isocitrate dehydrogenase.

B. Pyruvate carboxylase.

C. Cytochrome oxidase.

☒ D. Succinate dehydrogenase.

E. Pyruvate dehydrogenase.



Complex III



Cytochrome C reductase

“b-c₁ Cytochrome Complex”

It transfers electron from QH₂ to cytochrome C.

Pumping of protons across the inner mitochondrial membrane occurs.

associated with Proton Pump !!



III

Cytochrome b

e⁻

e⁻

H⁺

H⁺

Cytochrome

IV

Cu⁺

Cytochrome aa₃

09/11/24

CPS module.



Complex IV “cytochrome C oxidase complex”



It is a large enzyme (**Cytochrome aa₃**)

It contains

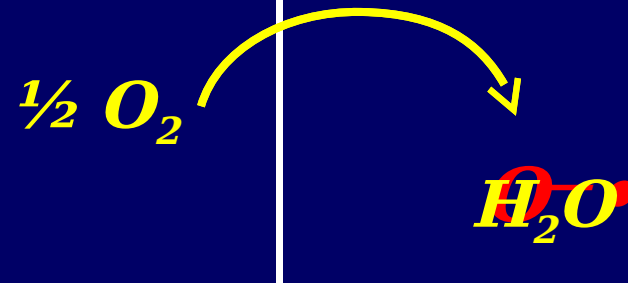
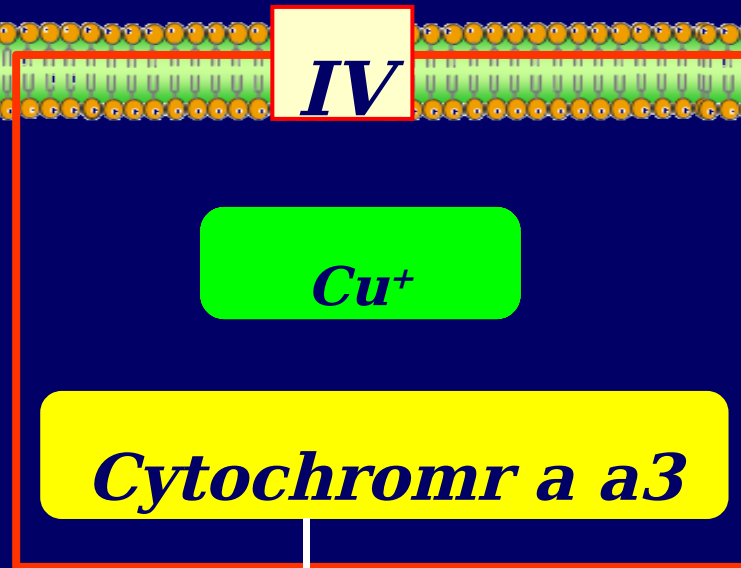
2 heme groups “cyt **a** & **cyt a₃**”

2 Cu ions

***catalyzes the transfer of electrons
from reduced cyt c to molecular
oxygen***

associated with Proton Pump !!

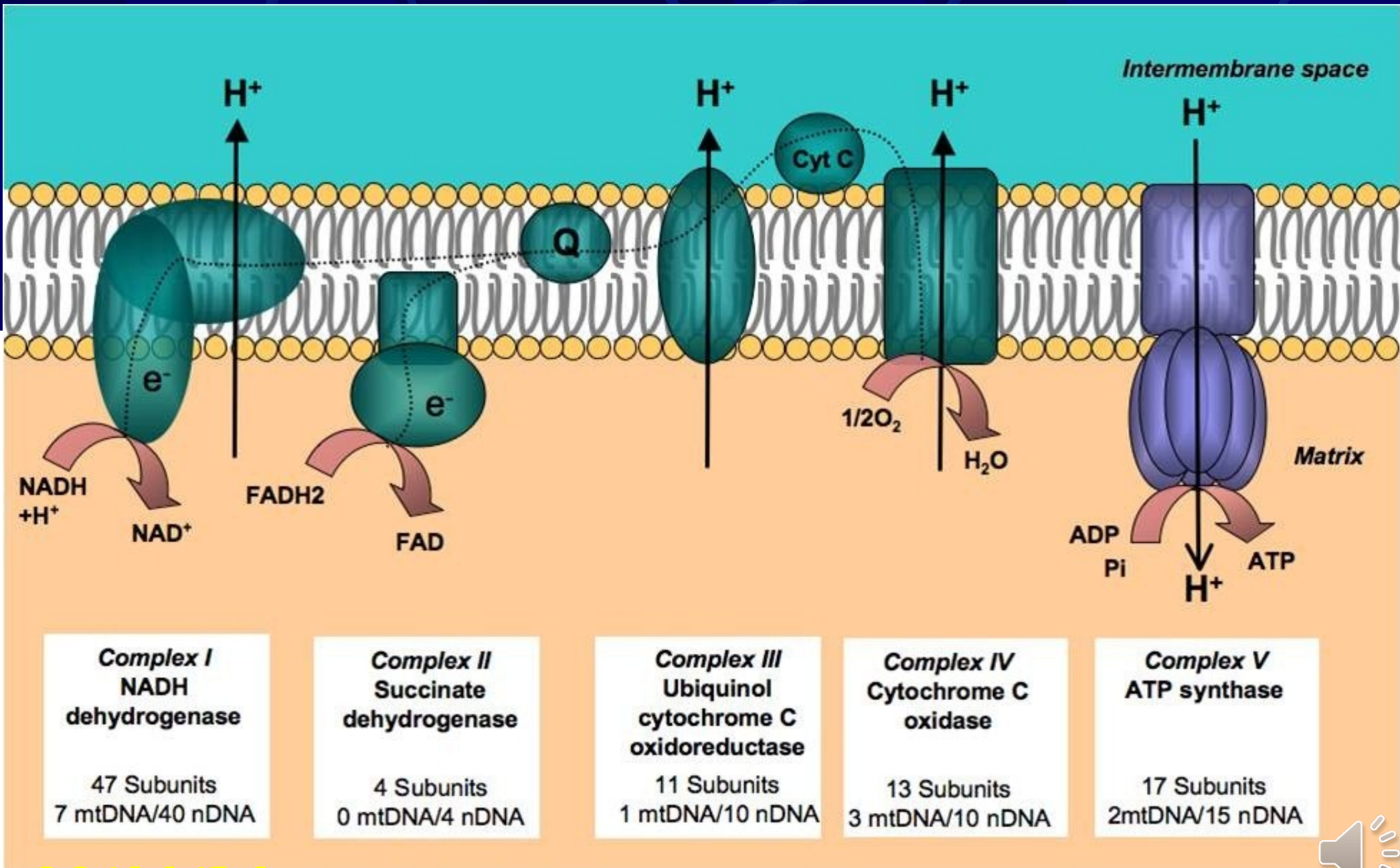




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CPS module.





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Student activity

- Which of the following has the strongest tendency to gain electrons?
- A. Coenzyme Q
- B. Cytochrome c
- C. Flavin adenine dinucleotide
- D. Nicotinamide adenine dinucleotide
- E. Oxygen

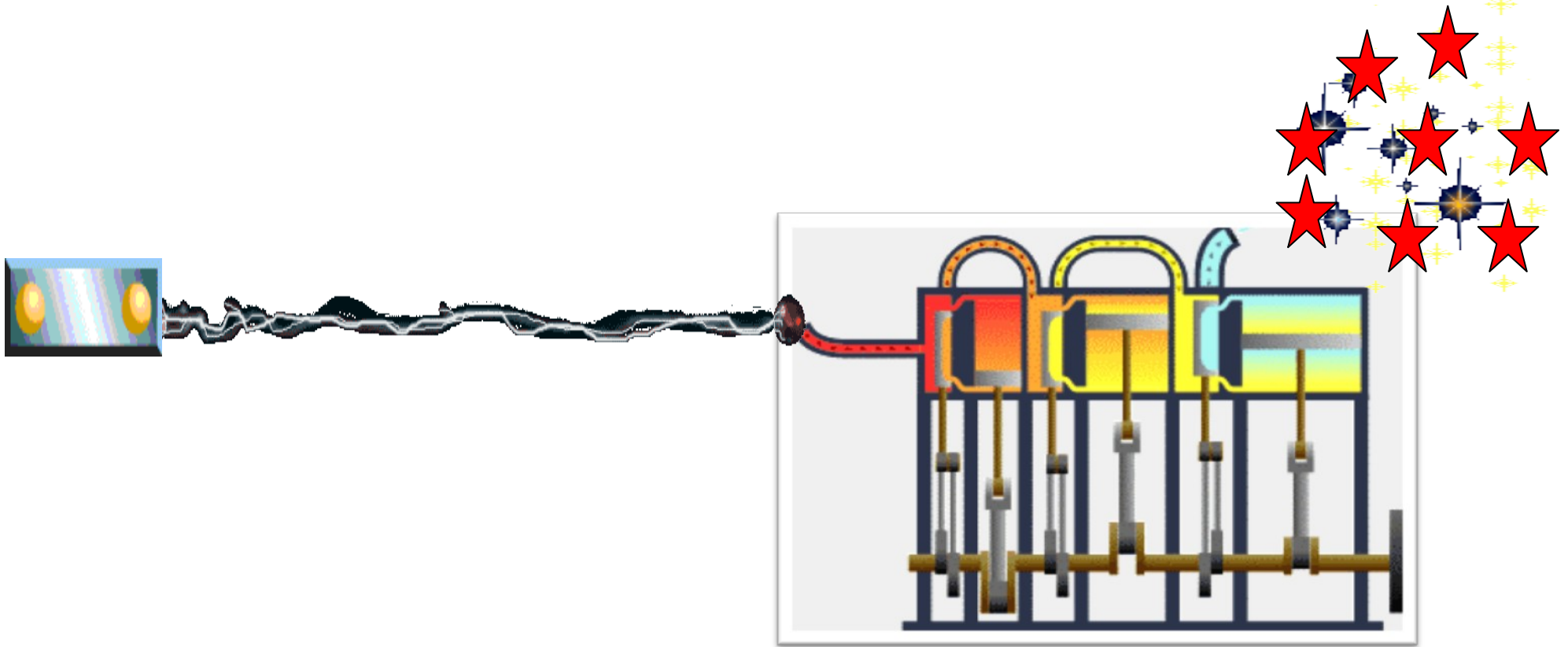
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CPS module.



Complex V

(ATP synthase Complex)

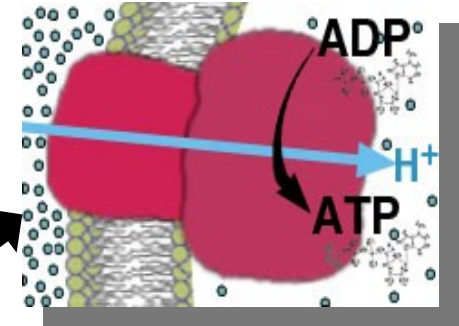
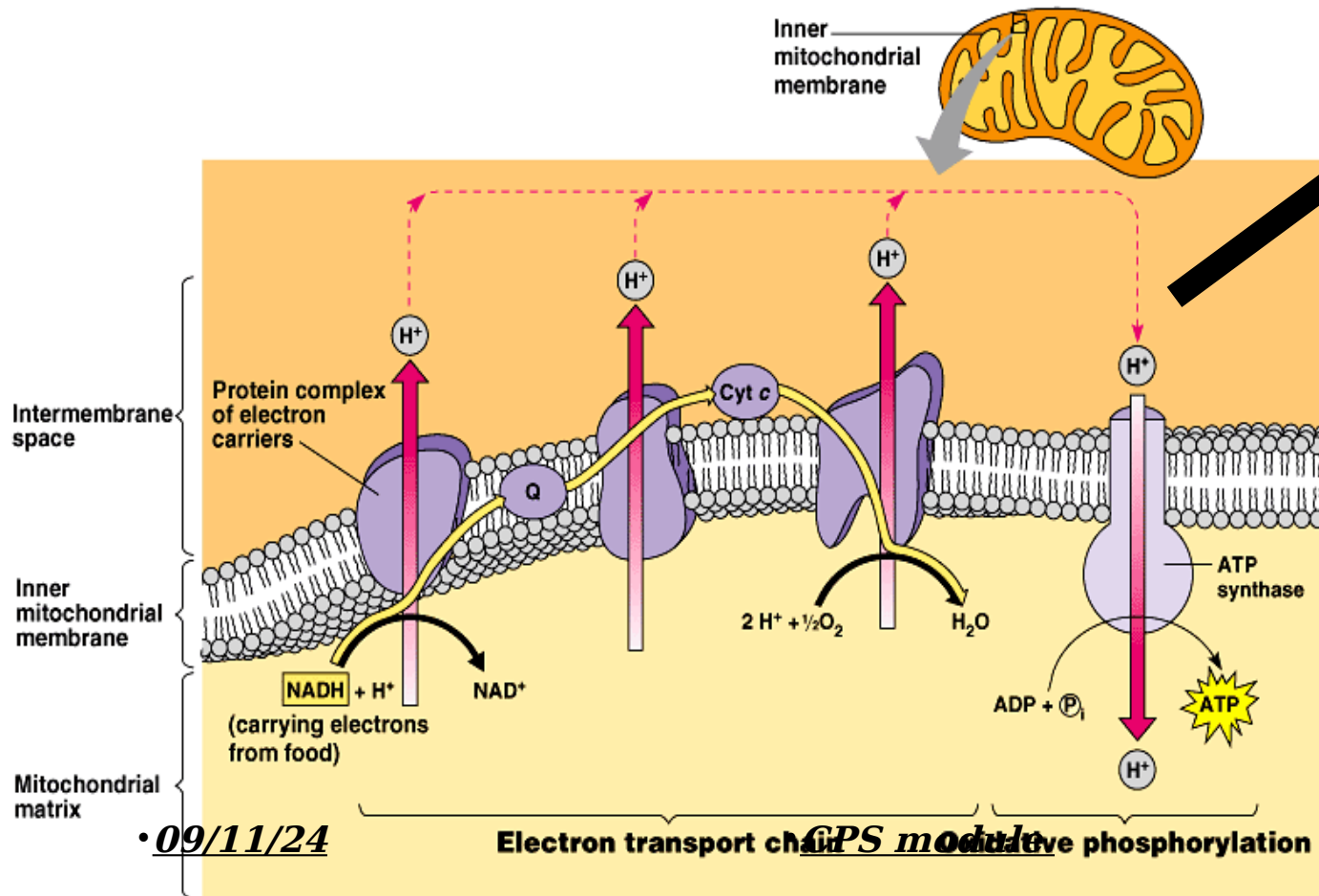


Chemiosmotic Model

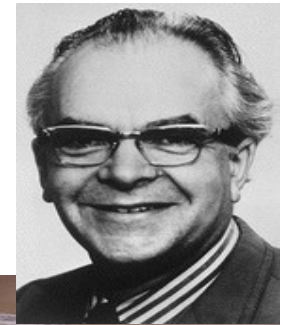


How is oxidation coupled to production of ATP?

Peter Mitchell Proposed chemiosmotic



1920-1992



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Electron transport chain

GPS module

oxidative phosphorylation



Chemiosmotic Model



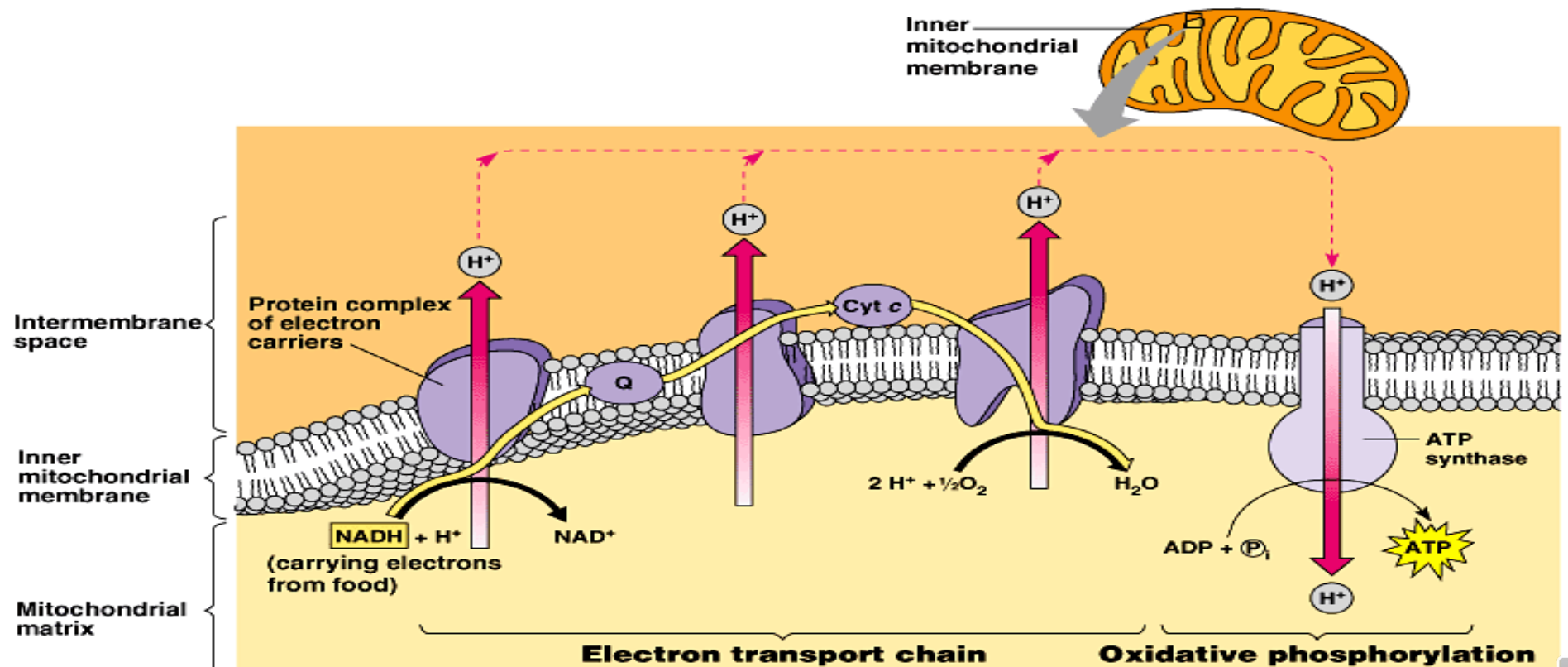
The theory postulates that the **energy** **obtained from oxidation** is coupled to the **translocation of protons H^+** from the mitochondrial matrix to the inter-Membrane space.

- **Complexes I, III, IV act as proton pumps.**



So an electrochemical gradient is created across the inner mitochondrial membrane.

(outside is +ve, inside is negative)

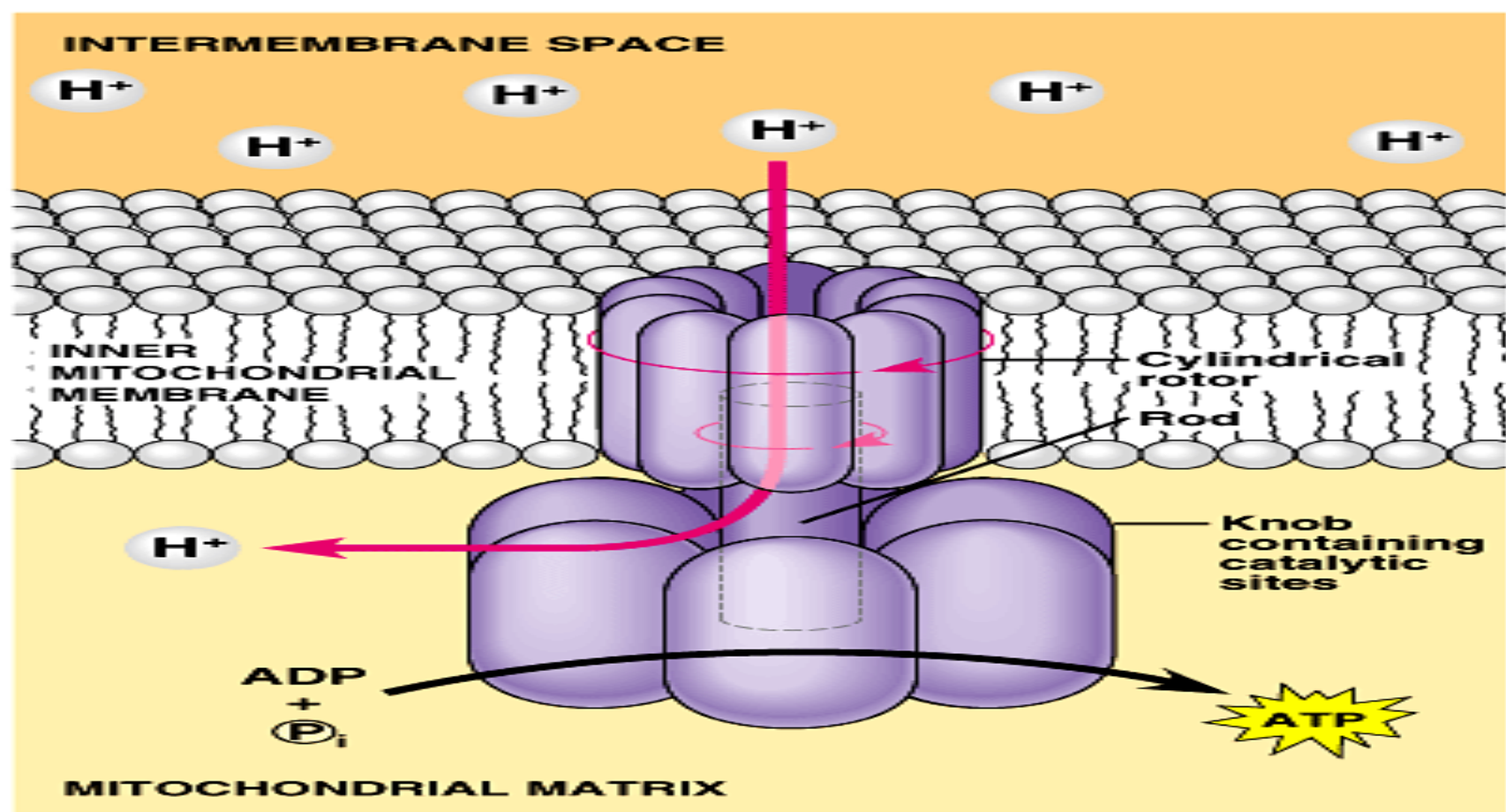


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•CPS module.

F₀

F₁



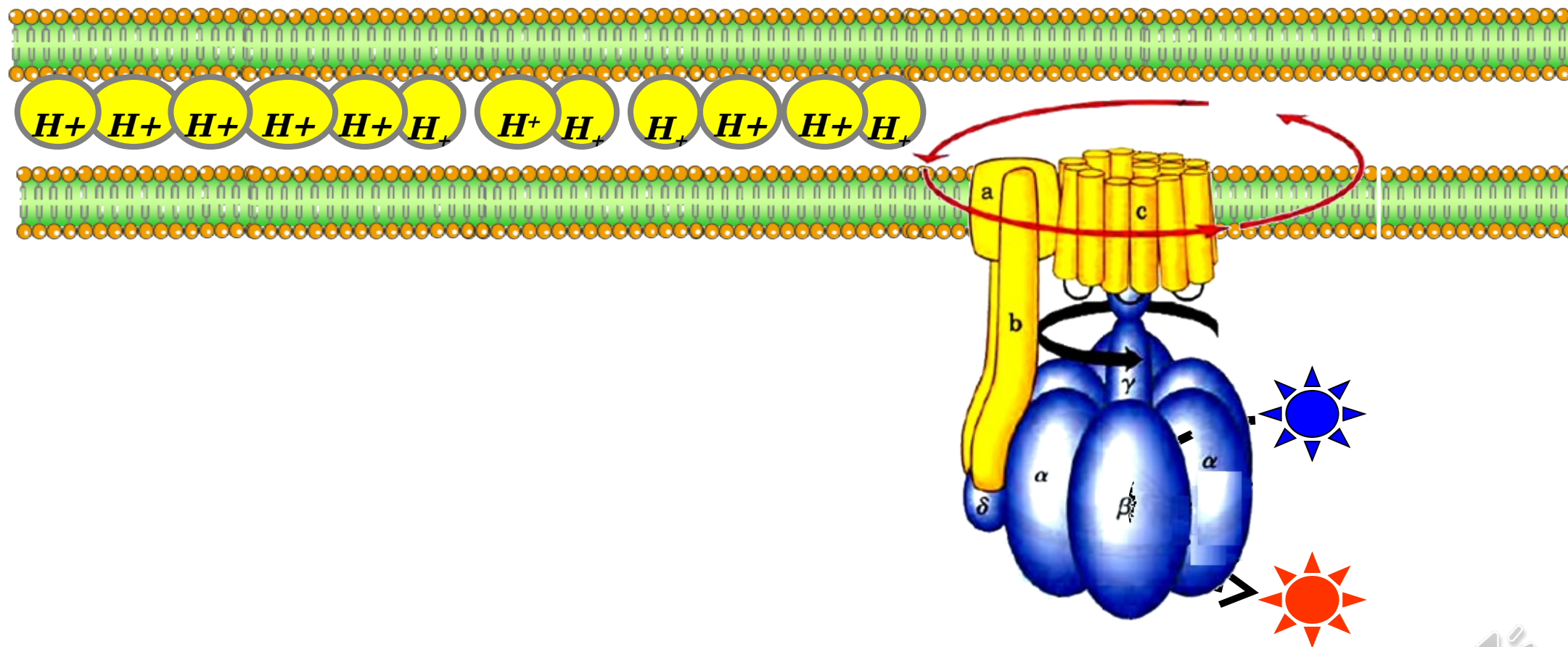
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Scattered on the surface of the inner mitochondrial membrane are units of the ATP-synthase.

It is inhibited by oligomycin.



Step wise production of Energy in the form of ATP is a physiological behavior



P/O ratio



It is a measure of the **number of ATP produced** during transfer of **2 e⁻ in the ETC.**





For 2 electrons transferred through the ETC there are **protons** pumped out side at *3 complexes (I, III & IV)* if it is through **NADH**

&

The **protons are** pumped outside at **only 2 complexes (III & IV)** if it is through **FADH₂**



Therefore



When substrates are oxidized via

NADH-linked dehydrogenases

3 ATP are produced per $\frac{1}{2}$ **O₂** consumed and this is given the term that they have a **P/O ratio of 3**.

On the other hand when a substrate is oxidized via a ***flavoprotein-linked dehydrogenase***

only **2 ATP** are produced
and it has a **P/O ratio of 2**.



Respiratory control



1. Mainly by availability of ADP.

2. Availability of electrons:



NADH/NAD ratio of



FADH₂/FAD.

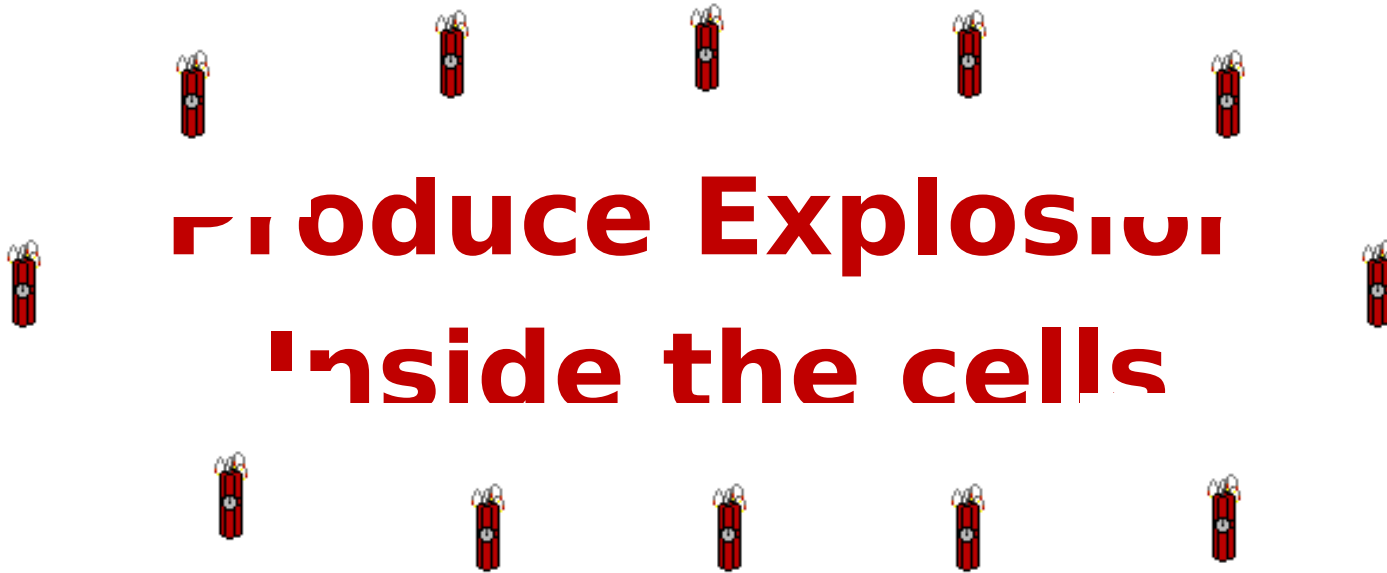
3. Availability of O₂.



***Rapid extraction of the
energy from reducing
equivalents will***



**produce Explosions
inside the cells**



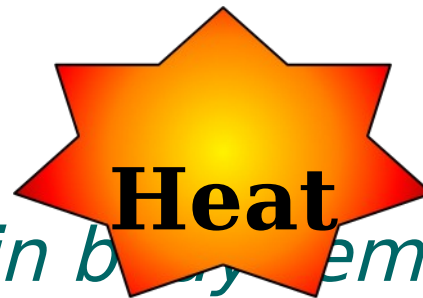
So Energy Production must be produced in



- Stepwise
- Controlled

40% of Energy will form ATP

The remaining free energy is liberated as



To maintain body temperature.





All of the following statements about the complex that carries out the synthesis of ATP during oxidative phosphorylation are correct except:

- (A) It is located on the inner mitochondrial membrane.
- ☒ (B) It is inhibited by Oligomycin
- (C) It contains F^o and F1 subunits
- (D) It can bind molecular O_2
- (E) It is called complex V





Which of the Following is oxidized by the respiratory chain?

- a. NADPH
- b. Acetyl CoA.
- c. Oxygen.
- ☒ d. NAD+.
- e. NADH



Student activity

Which of the following mitochondrial enzymes is FAD dependent?

A. Isocitrate dehydrogenase.

B. Pyruvate carboxylase.

C. Cytochrome oxidase.

☒ D. Succinate dehydrogenase.

E. Pyruvate dehydrogenase.

SUGGESTED TEXTBOOKS



- ***"Lippincott's Illustrated Reviews in Biochemistry" by P.C.Champe, R.A.Harvey and D.R. Ferrier.***
- ***"Harper's Biochemistry" by R.K.Murray, D.K.Granner, P.A. Mayes and V.W. Rodwell.***

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